NBS REPORT
7213

MULTICHANNEL INSTRUMENT TAPE RECORDER SYSTEM FOR AIRCRAFT

M. J. Vetter

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
BOULDER LABORATORIES
Boulder, Colorado

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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
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by

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1. General Description

This recorder system was developed primarily to be used for battery operation in conjunction with an airborne refractometer. However, it is quite versatile and can be used in many instrumentation problems requiring accurate recording in the range of 0 - 90 c/s. Solid state components are used throughout in the plug-in printed circuit cards.

2. Specifications

Size: 7 -9/16 in. x 10-7/16 in. x 15-11/16 in.

Weight: 16 lbs

Power: 22 to 30 v d-c Record: 0.37a: Playback: 0.35a (Motor 0.15a)

Tape: 1/2 in. on 5 in. reels

Tape speed: 1-7/8 in. per second plus fast forward and rewind

Recording time: 1 hr and 36 min with 1 mil tape

Number of channels: 7; 5 data, 1 compensation, 1 audio

Type of recording: wide band FM saturation

Input level: 1 v rms for ± 40% deviation. Gain control for higher input levels

Input impedance: 10 K unbalanced to ground

Number of playback discriminators: 4; 3 data, 1 compensation

Output level: 10 v p-p at 3 ma unbalanced to ground

Output impedance: less than 100 ohms

Bandwidth: 0 - 90 c/s ± 1 db with 500 c/s carrier

Noise level: down at least 40 db from full scale for 0 - 90 c/s

Linearity: less than 1% deviation from best straight line

The functional diagram is shown in figure 1.

3. Recording Oscillators

Six recording oscillators are provided (fig. 2), including a reference oscillator. This reference unit is identical to the others but has no provision for external modulation.

These voltage controlled oscillators are based on a very stable and linear saturable core device and a d-c amplifier having a high degree of negative feedback. The input to this amplifier consists of two transistors in a complementary design to give good temperature, stability, and gain characteristics. Controls on the oscillator cards consist of center frequency, input zero and a gain control that preserves the complementary conditions of the input amplifier regardless of changes in gain or input impedance.

Each VCO requires approximately 8 ma at 18 v and will supply 3 ma rms or more to a recording head. Carrier frequency may be changed by replacing the saturable core toroid but the simplicity of the complete oscillator does not justify the use of plug-in toroids.

4. Discriminators

The four discriminators (fig. 3) may be used simultaneously, three as data discriminators and one to supply wow and flutter compensation voltage to the others. This compensation

voltage is added to the data channels in two fashions. One addition is made to be effective under conditions of maximum excursion of the carrier frequency. This requires a phase delay in error voltage and, consequently, gives poor compensation for high frequency components. A second addition is made, with matched phase characteristics, to be effective primarily for high frequency components.

The compensation discriminator also supplies a "return to zero" voltage to the data channels, should there be a loss of carrier. One control, a centering adjustment, is provided on this discriminator card.

The data discriminators are similar to the compensation unit. A more elaborate output amplifier is added to provide good band-pass response, zero output voltage at center frequency, and limiting of output voltage together with a "return to zero" provision Two controls are provided on these cards, centering and output gain.

A simple three-transistor amplifier receives the recorded carrier from the tape and in turn triggers a pulse generator to provide precisely controlled pulses for the pulse counter. Triggering will take place with as little as 25μv from the head.

5. Altitude Transducer

A self-contained altitude transducer (fig. 1) provides a d-c voltage proportional to altitude in the 0-50, 000 ft range. A VCO designated "5A" is normally reserved and calibrated for use with this transducer.

6. Audio System

Provisions are made for recording and playback of voice (fig. 6). The input impedance is high (for a crystal microphone, etc.) and the class B output amplifier provides adequate power for the self-contained speaker.

7. Power Supply

Regulated voltages of + 18 v, + 15 v, + 10 v and - 10 v are developed for use within the equipment (fig. 5). The + 18 v and - 10 v supplies are adjustable with the - 10 v supply being set to within ± 0.1 volts of the + 10 v supply. A diode in series with the primary power source removes the danger of reversing the polarity of that source.

8. Operation

To record -

Information to be recorded is introduced on any of the five BNC connectors at the rear of the instrument, together with microphone and power connections. "REC - CAL - P. B." switch should be on "REC". "MONITOR" switch should be at "A" (discriminators B, C, and compensation are disabled during record). "DISCRIMINATOR A" switch indicates which recording channel is being monitored and, unless the compensation channel ("COMP CHAN") switch is at "IN", the condition of that channel is then shown on the panel meter. If the meter exceeds its limits on any channel, the modulation to that channel should be reduced. The "TRANSDUCER" switch controls the input to channel "5A" and should be on "OP" to record altitude or on "EX" if this channel is

required for other purposes.

The "AUDIO GAIN" control should be set by experience with the type of microphone used.

The "B" and "C" "DISCRIMINATOR" switches are not used during record and their positions are immaterial.

Knobs to operate fast forward and rewind clutches are positioned beneath the tape deck and are engaged by a clockwise movement. These controls should never be operated with the motor switch on and only the motor switch should be used to start or stop the tape.

To playback -

The outputs of discriminators "A", "B", and "C" are connected to appropriate recording mechanisms through connectors at the rear of the instrument.

"REC - CAL - P. B." switch is on "P. B." (A red light glows on "REC" and "CAL" indicating that previously recorded tape will be "wiped off" if operated under these conditions). The "MONITOR" switch should be on "A", "B", or "C" depending upon which discriminator is to be monitored on the panel meter. The compensation channel ("COMP CHAN") switch will normally be at "IN", though it may be switched to "OUT" if no compensation voltage is desired.

The three data discriminators may be connected to any of the five data channels by the positioning of the three discriminator switches. It is not recommended that more than one discriminator be connected to the same data channel simultaneously. The same audio gain control is used for both record and playback

and is set to operator's convenience.

To calibrate -

With the main function switch at "CAL" all components of the system are activated and may be interconnected and operated under a wide variety of conditions.

The "MONITOR" switch allows the meter to check the full scale output of the three discriminators. Center reading of the meter indicates center frequency (500 c/s), extreme left or -5 volts indicates "center frequency - 40% " and extreme right or + 5 volts indicates "center frequency + 40% ". This switch on "Bt." (beat) also allows the meter to visually indicate zero beat between the reference oscillator and any one of the five data oscillators as indicated by the positioning of "DISCRIMINATOR A" switch.

The compensation channel ("COMP CHAN") switch supplies a reference voltage of approximately + 10 v to the data discriminators. At position "IN" this voltage is produced by the compensation discriminator, otherwise by a fixed source. This switch also provides a - 40% and a + 40% modulation to the reference oscillator, so that on "CAL" and in conjunction with "MONITOR" switch and "DISCRIMINATOR A" switch, any data oscillator may be visually zero beat against the reference oscillator at - 40% and + 40% in addition to the center frequency. Also any data discriminator may be excited by the reference oscillator so that the meter and the discriminator itself may be calibrated at the center and either extreme.

The transducer switch, in addition to "OP" and "EX",

has four calibration positions for recording oscillator "5A". These positions, "0", ".25" ".5", "1.0" are respectively equivalent to, 0-12,500 ft - 25,000 ft - 50,000 ft on the output potentiometer of the altitude transducer.

The frequency and recording current, supplied by any one of the six oscillators, may be checked externally by a monitor connection at the rear of the unit. The channel appearing at this point is indicated by the position of the "DISCRIMINATOR A" switch. This information may be used at either "REC" or "CAL" position of the main function switch.

Use of the aforementioned information allows easy calibration of the ten printed circuit cards. The oscillator cards are normally set at center frequency for zero input voltage An exception is card "5A" which is offset to accommodate the altitude transducer, center frequency in this case being equivalent to 25,000 ft. Gain adjustments are set for full scale modulation at maximum input voltage and input zero adjustments are set to provide minimum frequency variation versus input impedance variations, when no input voltage is applied.

The single compensation centering adjustment matches the center frequency compensation voltage to that of the + 10 v supply. Changing the compensation channel ("COMP CHAN") switch from "IN" to "OUT", under these conditions, should provide minimum variation in the output of the data discriminators.

The data discriminator centering adjustments will provide zero output voltage from the individual discriminators when each is excited by a signal at the center frequency. The output gain

adjustments are set to provide a maximum output variation of 10 volts for a full scale modulation (- 40% to + 40%) of the carrier frequency

Figures 6, 7, and 8 show the complete unit and each of the three types of cards, VCO, data discriminator and compensation discriminator. The transport is a Model TT-100, Precision Instrument Corporation with a Honeywell head Model 1407AP.

LIST OF ILLUSTRATIONS

1. Functional diagram
2. Voltage controlled oscillator
3. Discriminators
4. Audio section
5. Power supply
6. Front view
7. Rear view
8. Printed circuit cards

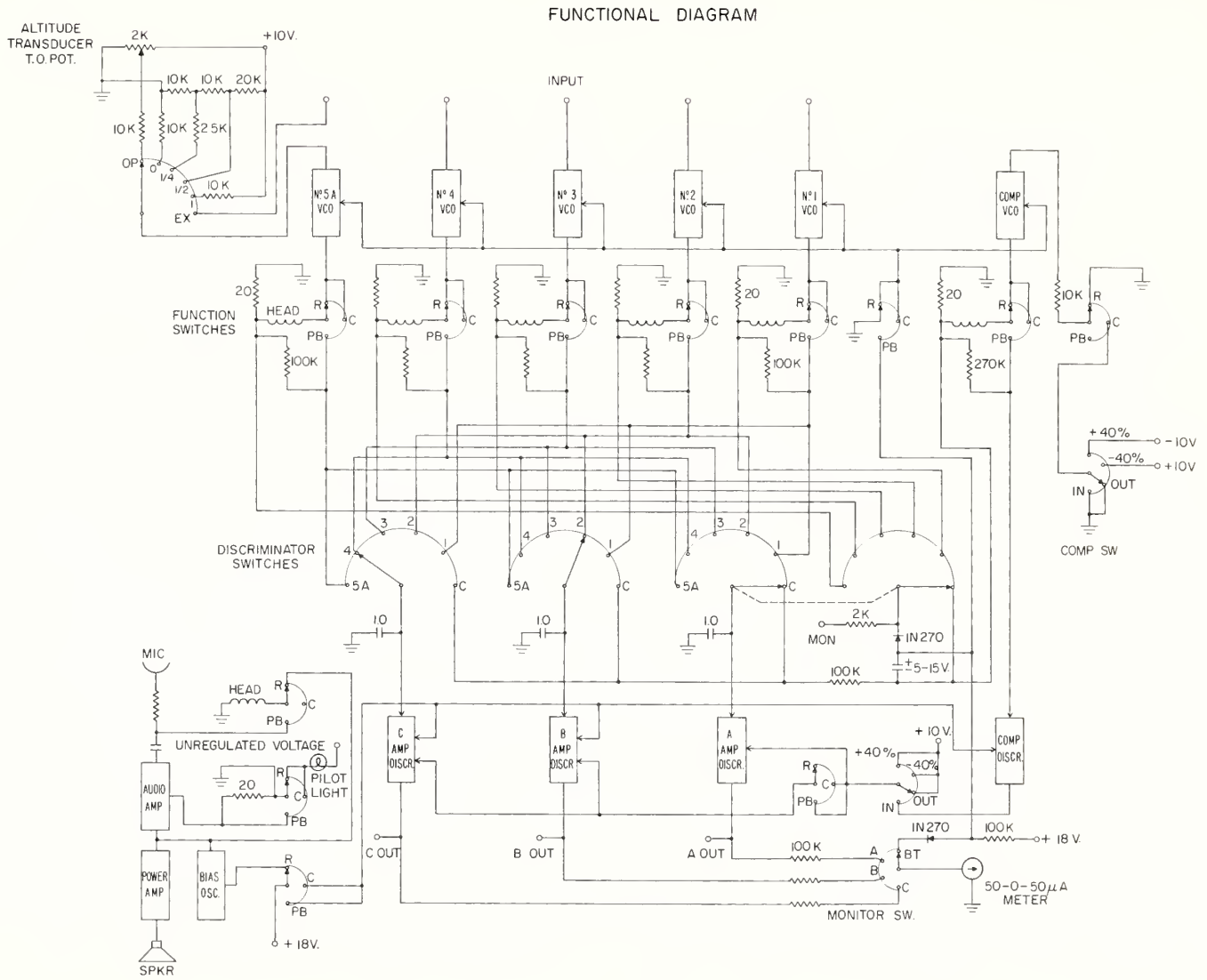

FUNCTIONAL DIAGRAM
ALTITUDE TRANSDUCER T.O. POT.
2K
+10V.
10K
10K
20K
10K
10K
2.5K
OP
0
1/4
1/2
1
10K
EX
INPUT
Nº5A VCO
Nº 4 VCO
Nº 3 VCO
Nº2 VCO
Nº1 VCO
COMP VCO
FUNCTION SWITCHES
20
HEAD
R
C
PB
100K
270K
10K
+40%
-40%
-10V
+10V
IN
OUT
COMP SW
DISCRIMINATOR SWITCHES
5A
1.0
2K
MON
IN270
5-15V.
100K
MIC
UNREGULATED VOLTAGE
PILOT LIGHT
AUDIO AMP
POWER AMP
BIAS OSC.
SPKR
+18V.
C AMP DISCR
B AMP DISCR
A AMP DISCR
COMP DISCR.
+10V.
C OUT
B OUT
A OUT
A
B
BT
+18 V.
50-0-50μA METER
MONITOR SW.

FIG. 1

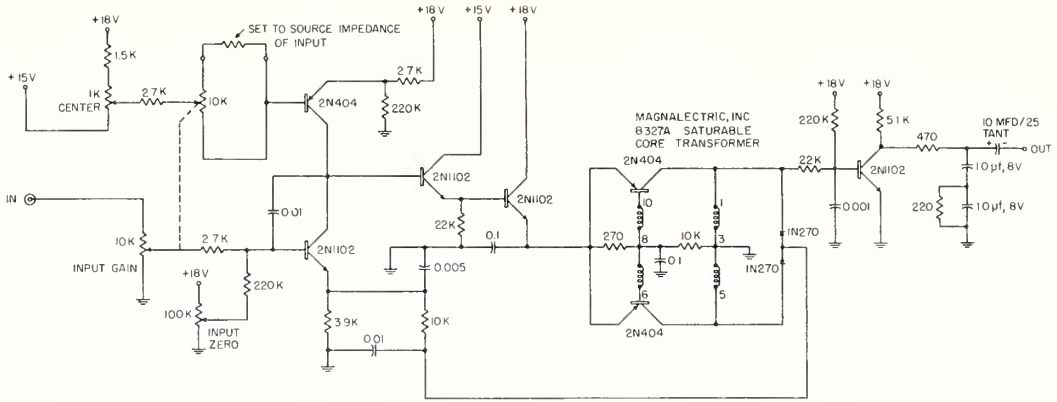


FIG. 2 VOLTAGE CONTROLLED OSCILLATOR

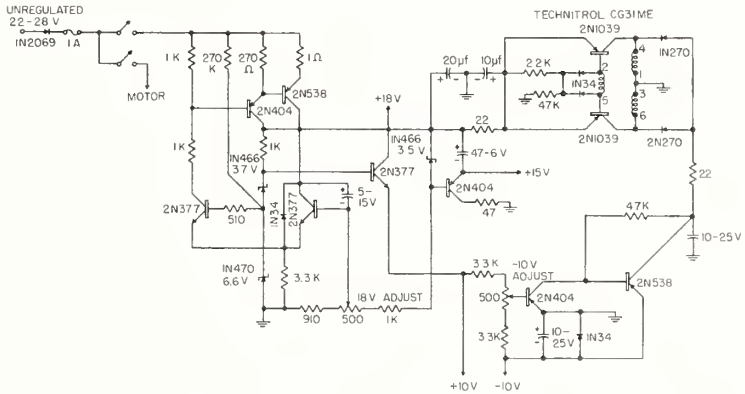


FIG 5 POWER SUPPLY

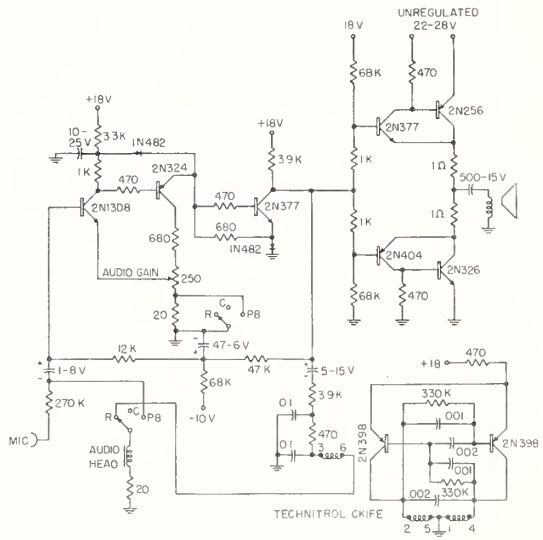
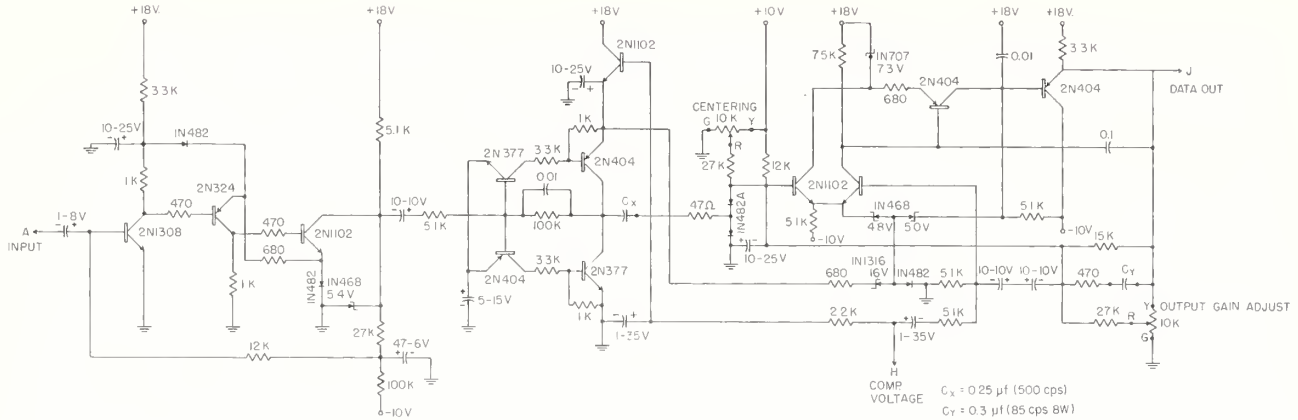


FIG. 4 AUDIO SECTION



DATA DISCRIMINATOR

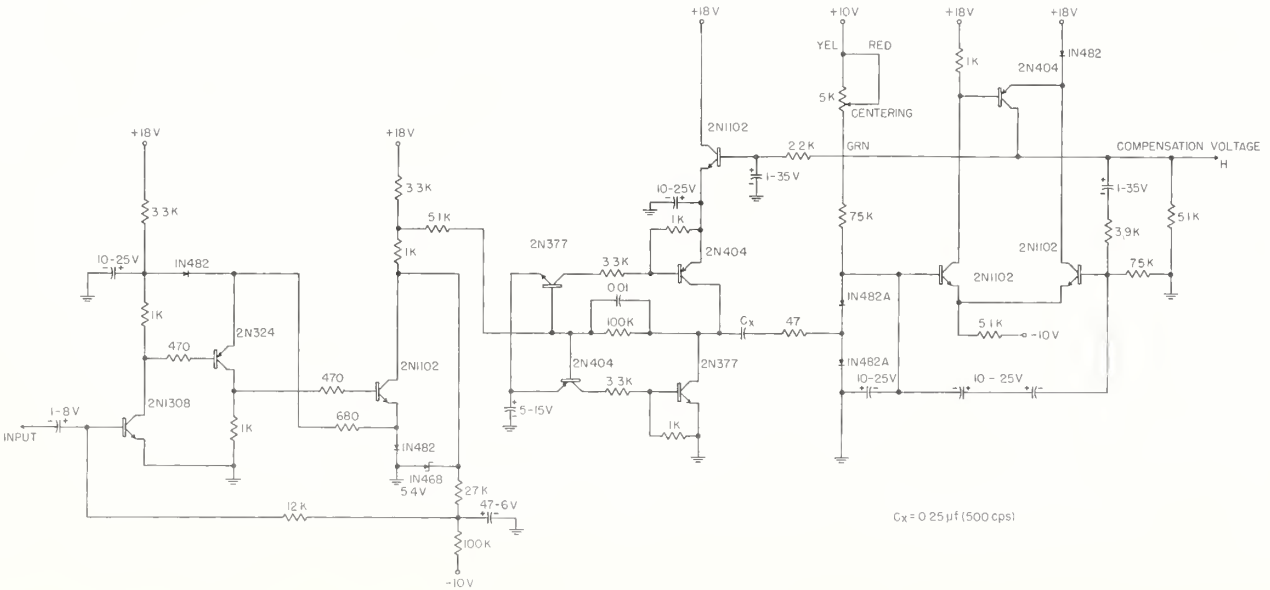


FIG 3 COMPENSATION DISCRIMINATOR

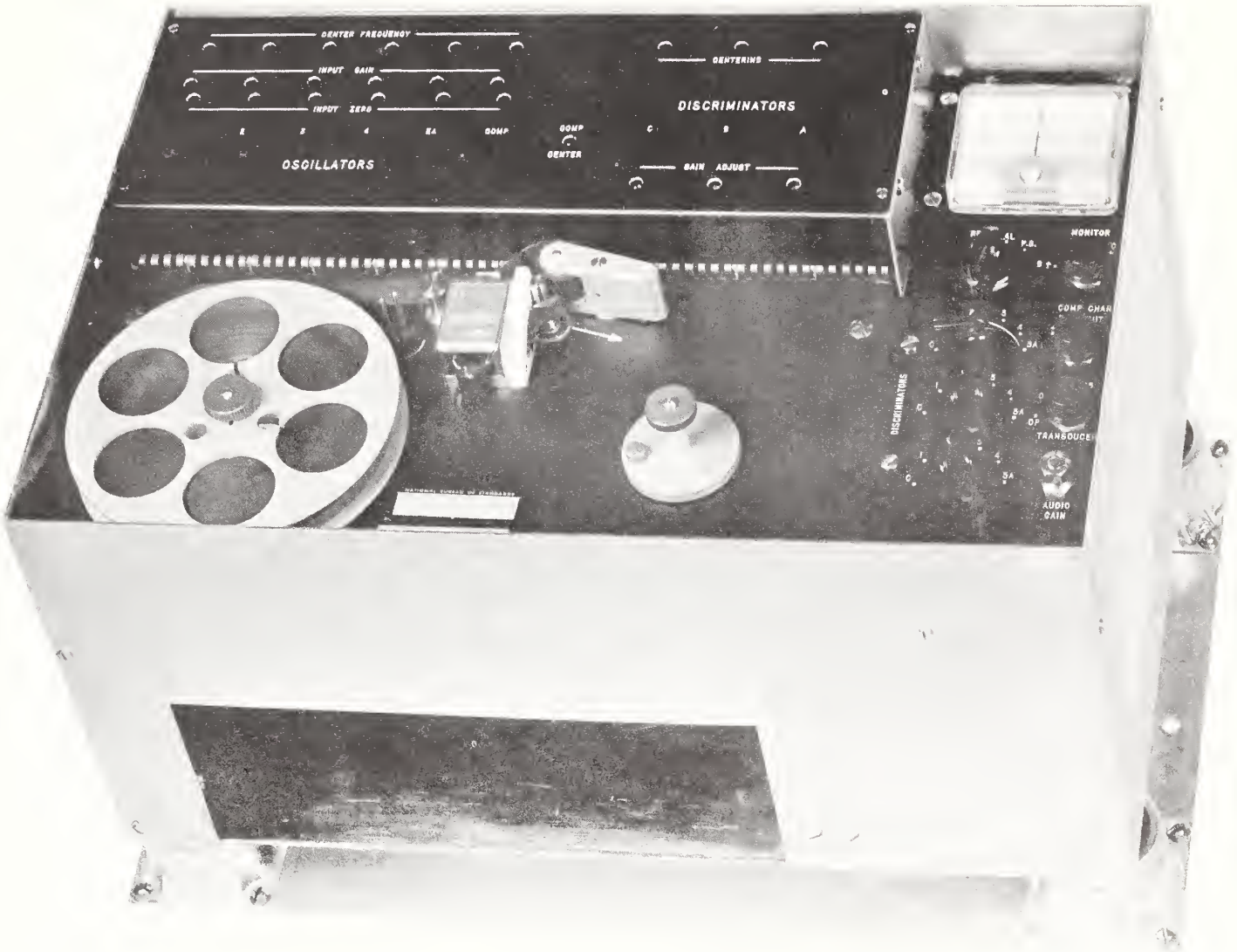


FIG. 6 FRONT VIEW

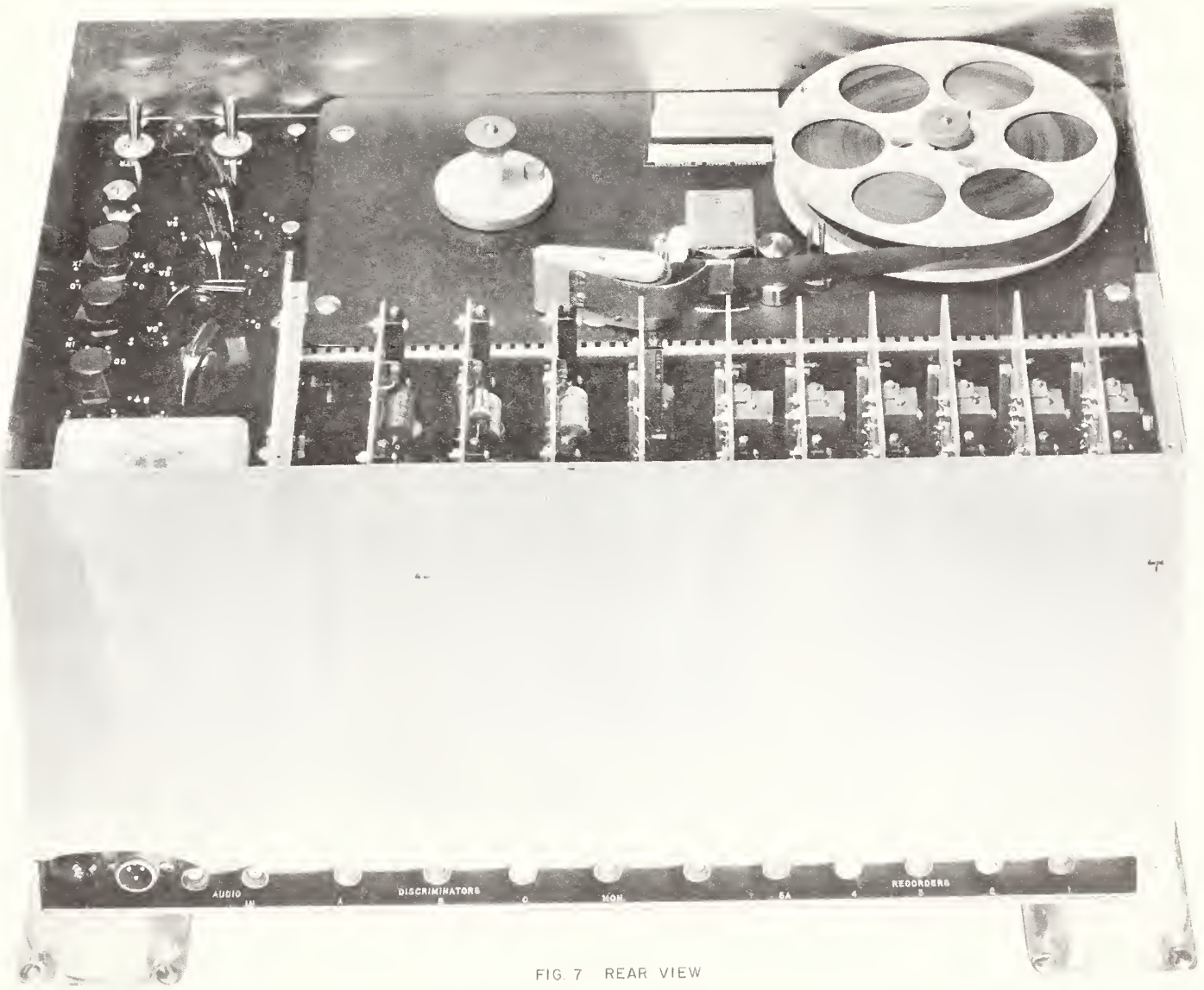
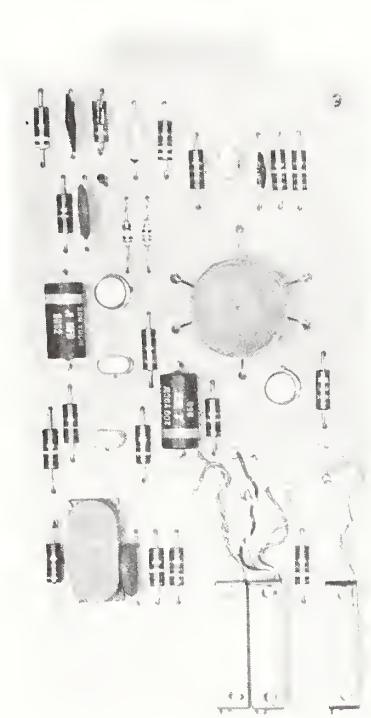
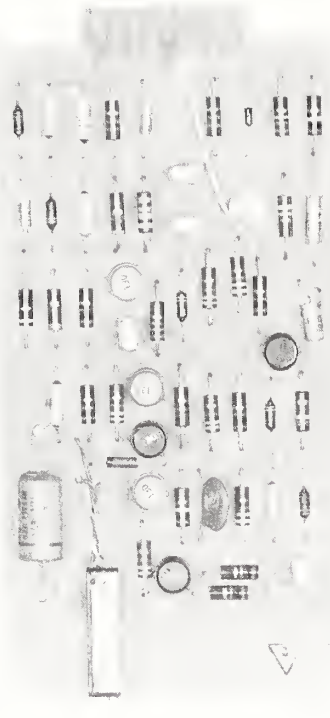


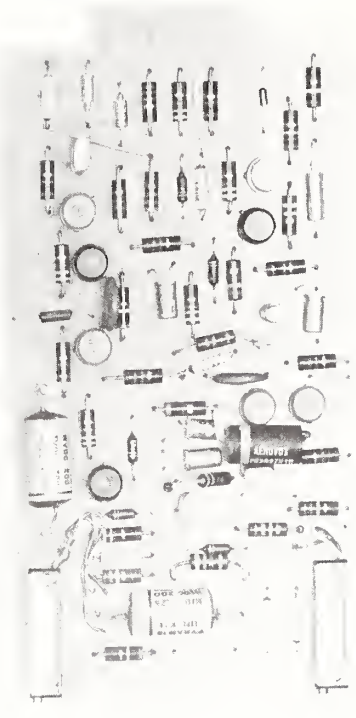
FIG. 7 REAR VIEW



VCO



DATA DISCRIMINATOR



COMPENSATION DISCRIMINATOR

FIG 8 PRINTED CIRCUIT CARDS

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Luther H. Hodges, *Secretary*

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